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CALIFORNIA ENERGY FLOW IN 1988

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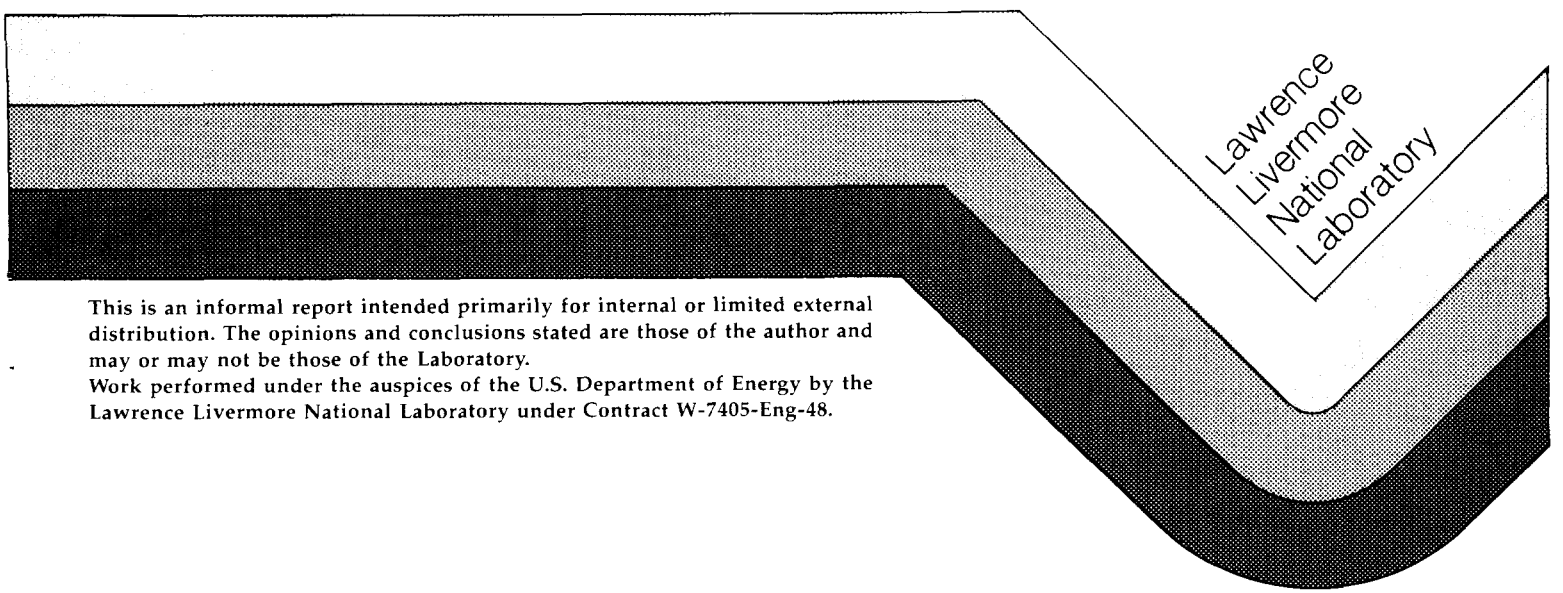
December 12, 1989



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ABSTRACT

California's energy consumption has shown a steady increase since the fall in oil prices in 1986 despite unusually mild weather over the period which is customarily associated with a decline in fuel use. While residential/commercial and industrial usage remained at 1987 levels, use of transportation fuels reached record highs. Some fraction of the increase reflected an increase in population and attendant increase in passenger miles driven; however the largest percent increases were registered by diesel-fueled trucks and vehicles. Accordingly on the supply side, oil use showed the largest increases.

California oil and gas production fell for the third year in a row. Demand for natural gas especially for enhanced oil production and the growing number of cogenerators and self-generators led to numerous pipeline proposals to bring additional gas into the state from both interstate and Canadian sources.

The State had an oversupply of generating capacity in 1988. Transmitted electricity was slightly below that recorded in 1987. Electricity from windpower increased to 1.82 billion kWh; nevertheless nominal installed capacity fell as inoperative and inefficient turbines were retired. The average capacity factor increased slightly to 17% - still below what the technology can realize. About 10% of the windpower produced was at times of peak demand. The Geysers, the State's largest geothermal field, began to show a decline in 1988. It is expected to continue in the coming years due to steam depletion at that location. Nonetheless a net total of 118 MWe of new capacity was added during the year as new fields in Sonoma and Lake Counties came on line.

The State's program to promote methanol as an alternate motor fuel moved ahead. There were about 700 methanol-fueled automobiles in public and government fleets operating in the state. The State legislature authorized the Energy Commission to order 750 new school buses. In addition General Motors signed an agreement to provide 2250 methanol-powered automobiles to the State for evaluation.

INTRODUCTION

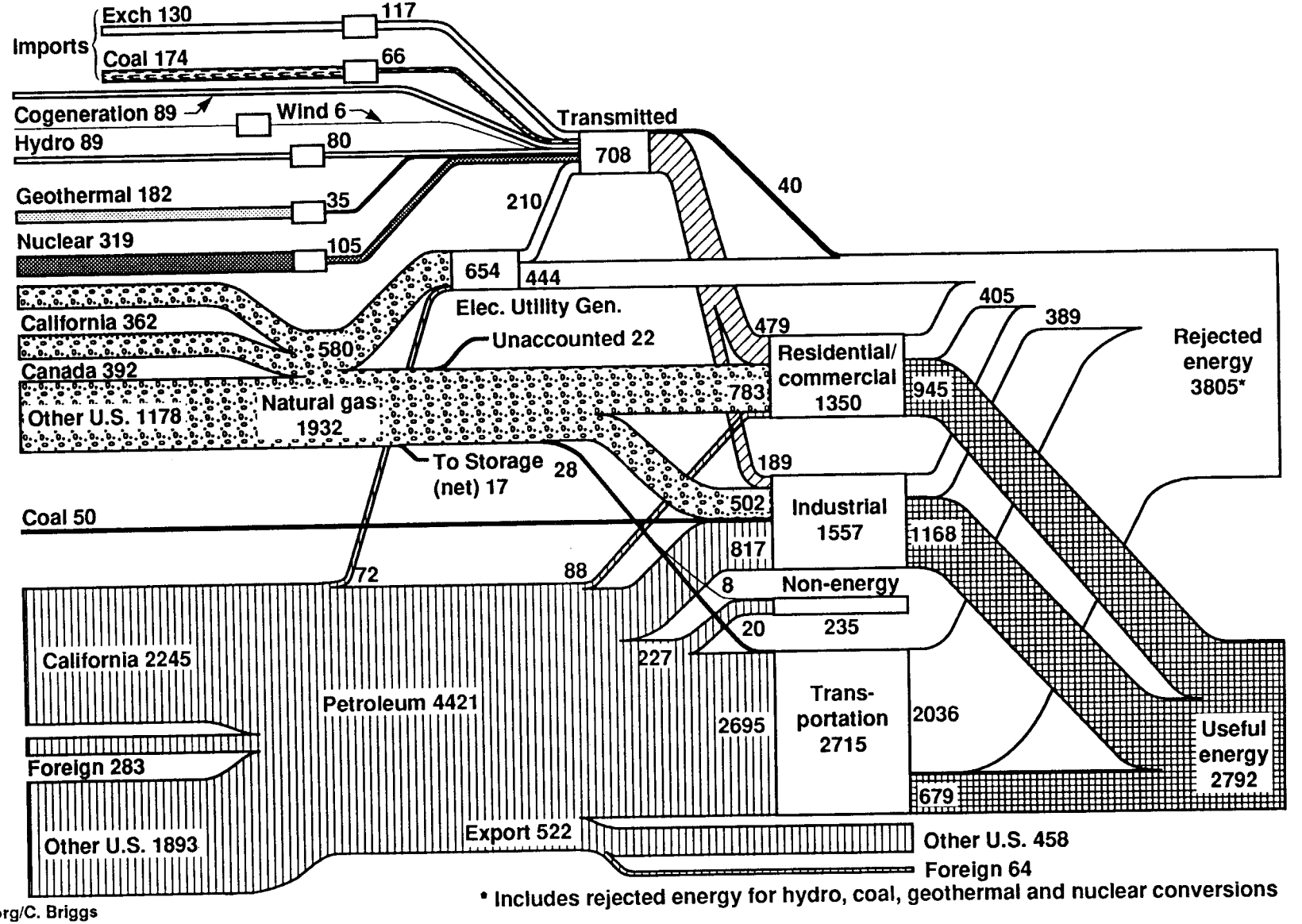
For the past twelve years energy flow diagrams for the State of California have been prepared from available data by members of the Lawrence Livermore National Laboratory.[1-6] They have proven to be useful tools in graphically expressing energy supply and use in the State as well as illustrating the difference between particular years and between the State and the U.S. as a whole.

As far as is possible, similar data sources have been used to prepare the diagrams from year to year and identical assumptions[2,3] concerning conversion efficiencies have been made in order to minimize inconsistencies in the data and analyses. Sources of data used in this report are given in Appendix B and C; unavoidably the sources used over the 1976-1988 period have varied as some data bases are no longer available. In addition, we continue to see differences in specific data reported by different agencies for a given year. In particular, reported data on supply and usage in industrial/commercial/residential end-use categories have shown variability amongst the data gathering agencies, which bars detailed comparisons from year to year. Nonetheless, taken overall, valid generalizations can be made concerning gross trends and changes.

CALIFORNIA ENERGY FLOW DIAGRAMS

Energy flow diagrams for 1988 and 1987 are shown in Figures 1 and 2 respectively. Energy sources are shown on the left and energy consumption is shown on the right. The energy balance between the two is given in Appendix A. Also shown on the right are estimates of conversion efficiencies in the end-use sector, which result in a division between useful and rejected energy. The latter consists primarily of heat losses but also includes other sorts of losses such as line losses during electrical transmission. Inputs to total transmitted electricity such as nuclear, geothermal power, etc., are associated with estimated efficiencies of the conversion process to electricity. They vary from 90% in the case of hydroelectric power to 18% for geothermal energy. Assumptions concerning the conversion efficiencies are given in Appendix D and their rationale can be found in Ref 2 and 3. The box separating the energy source from the final electrical output represents the conversion process. In all cases, the quantities associated with the energy source are calculated based on assumed conversion efficiencies. While it is desirable to minimize the number of assumptions in preparing an energy flow diagram, it is also desirable to express as closely as possible the energy content of the sources used during the year. In this way changes and improvements in overall fuel conversions that occur over the course of time by virtue of fuel switching and use of renewable sources such as windpower or solar energy have an expression in the total energy consumption in the state.

CALIFORNIA ENERGY FLOW - 1988
TOTAL CONSUMPTION 6750 $\times 10^{12}$ Btu



* Includes rejected energy for hydro, coal, geothermal and nuclear conversions

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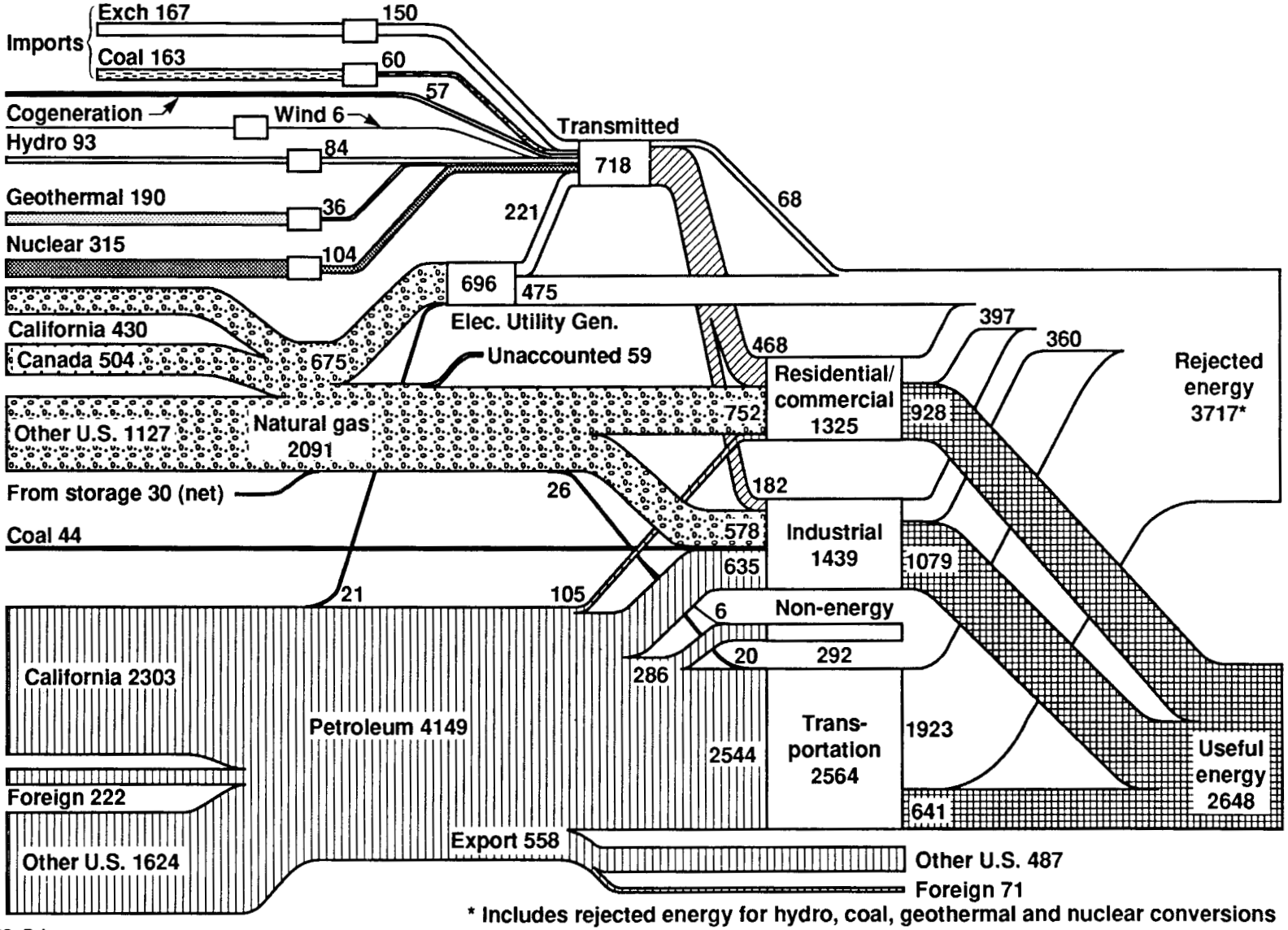
FL-059-U-8292-01

Figure 1

CALIFORNIA ENERGY FLOW - 1987
TOTAL CONSUMPTION 6600 $\times 10^{12}$ Btu



* Includes rejected energy for hydro, coal, geothermal and nuclear conversions

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FL-033-U-2615-01

Figure 2

Power from cogenerators and self-generators shown in the figures as inputs to total transmitted electricity appear without a box (representing the conversion process) that ordinarily would appear between the energy content of the fuel and the final product. In this instance, conversion losses are included in "rejected energy" from the industrial sector.

CALIFORNIA'S ENERGY FLOW IN 1988 COMPARED TO 1987

The state's energy use rose to record highs in 1988 (Table 1) due primarily to increased use of oil products for transportation. Temperatures recorded at weather stations at San Francisco, Los Angeles and San Diego (Table 2) were lower than "normals" for the 1961-87 period as they have been since 1983. Accordingly energy use in the residential/commercial sectors stood at 1987 levels. Similarly the combined energy use in the industrial and non-energy (petrochemicals, fertilizer, asphalt, etc) sectors was at 1987 levels.

A closer look at use of petroleum products for transportation in California (Table 3) shows that gasoline consumption increased a modest 2% while consumption of diesel fuel for highway vehicles increased 40% and use of aviation fuels increased almost 10%.

The mix of fuels used in California historically has been dominated by crude oil and natural gas reflecting the state's indigenous production which is brought to California markets by an extensive distribution system. With the passing of time, the combination of increased demand and declining California oil and gas production has led to the need for imported fuels, which are now the principal source of supply. Coal has little or no role in the slate of fuels used within the state; however coal-fired plants in nearby southwestern states are partially owned by California utilities and provide power to the state.

The strong growth in electrical consumption in 1986 and 1987 gauged by amounts of transmitted electricity (Table 1) ebbed in 1988 as did the growth in non-farm employment.[7]

OIL AND GAS PRODUCTION

California crude oil production fell for the third year thus mirroring decline in production in the U.S. as a whole. The precipitous drop in world crude oil prices early in 1986 is generally agreed to be responsible. California production is particularly sensitive to prices since a large fraction (63%)[8] is recovered using enhanced recovery processes. Steam stimulation accounts for three-quarters of incremental production and waterflooding the remainder. At year-end a typical California heavy crude oil (API 13°) had a posted price of less than $9 per barrel[8], which is considerably less than the average U.S. refiner's acquisition price for domestic crude oil of $14.76 per barrel.[9] At less than $9 per barrel, there is little margin for profit since it is estimated that thermal enhanced oil recovery adds $4-6 per barrel to the cost.[10] In order to cope with lower prices and higher costs, producers in the state have turned to two economic measures: burning

Table 1

Comparison of Annual Energy Use in California

(in 10^{12} Btu)

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
Natural Gas	1724	1971	1910	2010	1893	1769	1865	2034	1697	2091	1932
Crude Oil (less exports)	3781	3967	3834	3650	3327	3329	3477	3580	3601	3591	3899
Transmitted Electricity	597	617	622	620	642	622	700	673	697	718	708
Residential/Commercial	1321	1398	1334	1370	1225	1268	1176	1325	1224	1325	1350
Industrial	1088	1216	1294	1400	1570	1395	1493	1648	1456	1439	1557
Non-energy	239	304	298	165	158	183	221	185	203	292	235
Transportation	2438	2478	2471	2430	2265	2313	2464	2384	2499	2564	2715
Total Energy Consumption†	6050	6500	6400	6300	6000	5900	6200	6400	6200	6600	6750

† Total is not sum of above figures because of rounding and inclusion of losses associated with conversion to electrical energy.

Table 2

Weather Comparison
1958 - 1988
Annual Heating Degree Days**

	San Francisco Federal Office Building	Los Angeles Civic Center	San Diego Lindbergh Field
1958	2332	849	805
1967	2978	1040	1380
1968	2942	850	1052
1969	3066	1032	1145
1970	3006	941	1137
1971	3468	1424	1657
1972	3240	918	1166
1973	3161	1066	1137
1974	3182	1084	1123
1975	3313	1548	1416
1976	2665	1128	793
1977	2888	911	747
1978	2599	1208	736
1979	2545	1160	902
1980	2799	597	590
1981	2819	506	573
1982	3195	975	913
1983	2386	602	623
1984	2648*	704	713
1985	2486*	921	1079
1986	1842*	473	843
1987	2150*	979	1201
1988	2194*	867	1102
Normal 1961-87	2756***	1204	1284

* CA. Mission Dolores - same historical data as for Federal Office Building
Source: Local Climatological Data for San Francisco, Los Angeles and San Diego, National Oceanic and Atmospheric Admin., National Climatic Data, Asheville, N.C.

** A "degree day" is a term that describes the relationship of energy consumption to outdoor temperatures. "Heating or cooling degree days" are deviations of the mean daily temperature from 65° F. For example for a day with a mean temperature of 40°F., the "heating degree days" would be 25 and the "cooling degree days" 0. Annual heating degree days are the sum for the year. Greater number of heating degree days means greater fuel requirements.

*** Revised by W.J. Koss, NOAA, September 7, 1988.

natural gas instead of lease crude oil to produce the steam and combining steam generation with cogeneration of electricity which is sold to utilities. Nevertheless with the prevailing prices for utility purchases at an all time low, it is questionable whether sale of cogenerated electricity can compensate for the drop in crude oil prices.

Table 3

California Transportation End Use
(in 10^{12} Btu)

	1982	1983	1984	1985	1986	1987	1988
Net gasoline	1345	1418	1413	1445	1543	1576	1612
Net aviation fuel	298	318	348	379	392	390	427
Taxable diesel fuel -public highways	161	168	201	207	218	174	244
Rail diesel	42	41	27	31	31	30	26
Net bunkering fuel	346	316	390	274	267	347	357
Military	36	35	40	33	35	28	29
Natural gas-pipeline fuel	n.a.	n.a.	11	12	15	13	20
Total	2228	2307	2431	2384	2499	2565	2715

n.a.: Not available
Source: Petroleum Marketing Annual 1988 DOE/EIA-0487(88)

Production declines were registered in onshore and state offshore fields. Only federal offshore production showed an increase; however it constitutes only 8% of total state production. The start of production at the large Point Arguello field in federal waters north of Santa Barbara was still blocked at year-end by the California Coastal Commission which objected to the plan to tanker the oil from the Gaviota processing plant to Los Angeles.[11] The Point Arguello field is believed to be the largest field discovered in United States offshore continental shelf; it contains upwards of 300 million barrels of oil.

Among the fields with diminished production was Elk Hills (Naval Petroleum Reserve No. 1), which is the fourth largest producer in the state and is second only to the Kern River field in estimated reserves. Before leaving office President Reagan in his final budget made one last effort to sell the Naval Petroleum Reserve by tying its sale to financing the filling of the national Strategic Petroleum Reserve (SPR).[12] The proposal calls for the sale in 1990 of both Elk Hills and Teapot Dome, Wyoming for a bonus payment of $1 billion. Under terms of the sale the purchaser would be required to deliver 50,000 barrels per day for five years to the SPR. Congress and the Navy have been reluctant to endorse the plan partially because the size of the field has not been firmly established and because the reserves were established in 1920 to guarantee the Navy oil in case of emergencies.

State natural gas production declined for the third year. The 16% decline of marketed production of dry gas to 345 billion cubic feet[13] brought it to 1983 levels, but still 100 billion cubic feet above lows recorded in 1978.[8] Declines were registered in all classes of gas production, i.e. offshore and onshore, gas not associated with oil production as well as associated gas.

NATURAL GAS SUPPLY

Natural gas is second only to petroleum as a source of energy to California (Figure 1), and demand is expected to grow with increasing use in enhanced oil recovery operations and because gas is the fuel of choice for the growing number of cogenerators and self-generators of electricity. As the State produces about 30% of its own natural gas, incremental supplies are expected to be from either Canada or other western states.

Numerous planned and proposed gas pipelines to bring natural gas into the state were before the Federal Energy Regulatory Commission (FERC) in 1988. They attest to the fact that a larger market is expected in the future. Of the eight proposals three (Wyoming-California Pipeline, a subsidiary of Coastal Corp.; Kern River Transmission Co., whose principals are The Williams Companies and Tenneco Corp.; and Mohave Pipeline Co. backed by Enron Corp. and El Paso Gas Co.) hope to serve the enhanced oil recovery market in southern areas of the state. In this capacity they would displace California oil now used to raise steam in steam flooding operations. The rule-of-thumb is that one barrel of oil out of every three produced is burned as boiler fuel in steam flooding operations. Air quality is one of the prime considerations in the use of natural gas as an alternate fuel. The burning of typically high sulfur petroleum produced at onshore California locations is no longer acceptable, and addition of pollution controls to existing facilities is more expensive than turning to a cleaner fuel, such as natural gas.

The remaining proposals are aimed at augmenting utilities' supplies that are marginal as far as serving the general population. During the summer of 1988 Southern California Gas Co. was forced to curtail gas deliveries. Prominent among the proposals is Pacific Gas Transmission Corporation's[#] proposal to increase the capacity of its 1 Mcf/d gas pipeline from Canada to 1.6 Mcf/d. Only a few of the proposed pipelines will be built. Even with permits from the Federal Energy Regulatory Commission, construction of the proposed pipeline is not assured as they are contingent on demonstration of adequate gas supplies as well as committed customers. At the end of the year the California Public Utilities Commission ordered the five major energy utilities in the state to work out among themselves a proposal on how to improve the pipeline system -meaning not only the actual pipelines but the contracts having to do with sharing and allocation of space.[14]

[#] A subsidiary of Pacific Gas and Electric Co.

ELECTRIC POWER

Source of Supply

California anticipates a continuing high growth rate in electrical power consumption in the next decade[15], the largest portion of which is associated with expected increases in population. The growth rate is estimated at 2.1% annually corresponding to a need for about 1 GW_e additional capacity per year. Nonetheless the utilities, who own 85% of the state's generating capacity, have plans to add only 224 MW_e to their grids between 1989 and 1992. Currently total nominal capacity is on the order of 50 GW_e (Table 4); although not all of it is available at any one time, the state is considered to have an overcapacity. Peak loads for the 1986-8 period have been in the 41-42 GW_e range. To meet growing demand, it is anticipated that qualified facilities** and self-generation will grow by 3.1 GW_e; conservation and load management programs will obviate the need for 2.0 GW_e and imported power will supply the remaining (0.27 GW_e) of needed power.[15]

In 1988 California's largest single source of electric power was gas fired generating plants (Table 5). Electric imports from other Pacific and southwestern states constituted the next largest source of supply. Oil-fired generating units contributed only a small portion of power although in 1988 the amount was a factor of four times larger than in 1987, which reflected the fall in the price of fuel oils.

Cogeneration

Utility purchases from cogenerators and self-generators continued to grow (Figure 3). These purchases under PURPA have contributed to California's current oversupply of electrical generating capacity.

Particularly unfortunate are some of the so-called "Standard Offer" contracts instituted by the California Public Utilities Commission as a way to simplify negotiations between the utilities and the qualified facilities. They have led to over-pricing to the utilities as a consequence of built-in annual increases over the life of the 15-30 year contracts, many of which were negotiated before the price of oil (and gas) fell at the end of 1986. Apparently the utilities anticipated oil prices as high as $69 per barrel by the year 1995.[21]

Nuclear Power

Electrical power production from nuclear energy decreased slightly from 1987 levels. Rancho Seco, the 913 MW_e plant outside of Sacramento was restarted in April after almost two years of repairs and ran at less than full power for the remainder of the year. In June it barely survived a

** A qualifiied facility under PURPA is a small power producer which produces less than 80 MWe of electricity from solid waste or renewable resources. Also included in the group are cogenerators that meet minimum size, fuel use and fuel efficiency requirements prescribed by rule by FERC.

Table 4

California Electrical Generating Capacity[16,17,18]

Primary Energy Source	Capacity (GWe)
Utility*	
Petroleum	3.16
Gas	21.09
Water	12.47
Nuclear	5.61
Other (principally geothermal)	2.10
SUB-TOTAL	44.43
Cogeneration	3.56
Wind	1.20
Biomass	0.21
Landfill gas	0.19
Small Hydro	0.18
Solar	0.18
Municipal solid waste	0.02
TOTAL	49.97

* Summer capability as of December 31, 1988

Table 5

Sources of California Utilities' Electricity- 1988[17,19,20]

Source	Net electrical energy (trillion Btu)	
Imports		183
Out-of-state coal facilities	66	
Purchases	117	
Fossil fuels		210
Natural gas	184	
Oil	26	
Nuclear power		105
Hydropower		80
Geothermal power		35
Windpower		6
Cogeneration		89
TOTAL		708

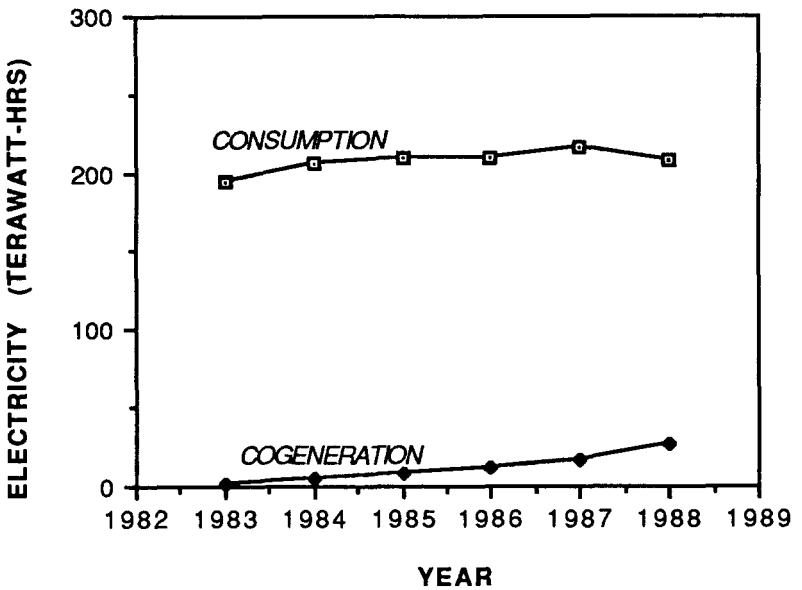

Figure 3 Contribution of cogenerated power to California consumption[15,22]

referendum to shut it down and instead was given an 18 -month reprieve or trial period. It has the dubious distinction of having been on almost everyone's list of "worst-performing nuclear plants" because of its lifetime capacity factor of 38% compared to the national average of 65%.* At year-end it faced another referendum in June 1989 to close it down.

The California Public Utilities Commission approved a rate settlement with Pacific Gas and Electric Company over the cost of the $5.8 billion Diablo Canyon nuclear power plant. The landmark settlement was geared to performance of the plant. The CPUC anticipates that rate payers would pay $3.5 billion of the total cost and utility stockholders the remainder; however if capacity factors can be maintained in the 65-70% range, the agreement allows higher rate increases to recover costs and consequently a larger share of the cost will be passed onto the rate payers.

Renewable Sources of Electricity

Geothermal Power

Of the 1667 MW_e summer generating capacity operating in the U.S., all but 24 MW_e is installed in California.[16] This represents a net increase of 118 MW_e over capacity existing at the

* Capacity factor expresses the number of kilowatt-hours actually generated by power plants as a percentage of the number of kwh that the plants were designed to generate in the same amount of time. Low numbers indicate less reliability.

end of 1987. New capacity consisted of the Coldwater geothermal plant (130 MW-gross) in Sonoma County, which supplies the Sacramento Municipal Utility District, and two smaller units in Lake County, the 30 MW (gross) West Ford Flat Power Plant #1 and the 23 MW (gross) Bear Canyon Creek Power Plant.[8]

Although capacity increased in the State, total production from geothermal sources declined 12% (compare Figure 1 & 2), due principally to the decline in steam production at the large vapor dominated steam fields at the Geysers. Geothermal energy is often described as a renewable form of energy; however steam production (pressure) curves resemble oil production curves in that decline ultimately sets in. To maintain production levels reworking of well-bores is standard and failing that, new wells are drilled to tap the steam or oil reservoir. Whether the last strategy is successful or not depends on numerous factors including size of the resource. In two geothermal fields (Bottle Rock, Lake Co. and South Geysers Plant, Sonoma Co.) initial investments were based on 30 year steam supplies which failed to materialize. Bottle Rock which was designed for a 54 MW_e generating plant can only supply steam for 20 MW_e, and the South Geysers Plant was mothballed in 1986 for lack of adequate steam supply.

Geothermal development in the southern part of the state has moved forward, particularly at the Coso Hot Springs area in Inyo County, and at year end 140 MW_e was about to be put on-line. Long Valley, on the eastern flank of the Sierra Nevada, is another geothermal site. Its development has been hampered by a growing debate on its environmental impact on ecosystems and local fish hatcheries.[23]

Windpower

Electrical output from wind turbines increased approximately 5% during 1988 - from a total output of 1.73 to 1.82 billion kWh.[17] Refer to Figure 1 or 2 for a perspective on the current role of wind power in the slate of generating technologies used to meet state demand. Although total output increased, total nominal installed capacity associated with wind power fell. The seeming contradiction is related to the dismantlement of inoperative and inefficient turbines. (Table 6). It is anticipated that the trend will continue as poor installations built in haste before the expiration of federal and state tax credits are retired. The number retired is larger than the turbine count in Table 6 might suggest since the count includes 564 new machines most of which were installed in the Altamont area, near Livermore. As a consequence of retirement of malfunctioning and poorly designed units in almost all areas of the state, the average capacity factor which is the ratio of actual output to the amount of energy that could be produced if operated at full rated power, 24 hours a day over a given period, increased slightly from 16% to 17%.[17] Thus average capacity factors are still below the 20-30% which is considered within reach of the technology.

Turbines in the 50-100 kW_e size range continued to dominate both new and old installations. Forty-two percent of the total operating capacity in 1988 was of foreign origin; however U.S. Windpower is the largest single manufacturer supplying turbines to wind farms in the state.

Table 6

Windpower Installations in California as of January 1

Location	Capacity (MW_e)				Number of turbines			
	1986	1987	1988	1989	1986	1987	1988	1989
Altamont Pass area, 45 miles east of San Francisco	524	584	654	623	5175	6219	6615	6062
San Gorgonio Pass, Riverside Co. near Palm Springs	197	295	254	206	2945	4155	3830	3322
Tehachapi Pass, Kern Co.	188	355	393	370	2733	4175	4480	4007
Mojave Desert, Kern Co.	(n.a.)	0	0		(n.a.)	0	0	
Boulevard, San Diego Co.	1.25	0.8	0.8		51	36	36	
Carquinez Strait, Solano Co.	.63	0	0.63	2	6	0	6	66
Pacheco Pass, San Benito Co.	(n.a.)	0.5	0.5		(n.a.)		20	
Salinas Valley	0.1	0.16	0.16		4	4	4	
TOTAL	911	1235	1304	1202	10914	14609	14991	13457

n.a.: Not available
Source: California Energy Commission, Results from the Wind Project Performance System 1985 Annual Reports, August 1986, 1987 and Sam Rashkin, personal communication 1989.

Flowind, among the five largest operators in the state, filed for reorganization under Chapter 11 of the Federal Bankruptcy Act. The company's capacity factor in 1988 was 10%[17], a reflection on mechanical problems with the unique, vertical axis wind turbines.

For the state's wind farms as a group 50-60% of the power produced and sold was "off-peak," i.e. not at times of high demand. Approximately 10% of the electric generation coincided with peak demand and, depending on month about 30% coincided with "mid-peak" demand. New contract prices paid for power by the purchasing utilities ranged from 2.5 to 3 cents per kWh depending on time-of-day. Contracts negotiated in previous years have involved prices as high as 8.9 cents per kWh for "on-peak" power.

Solar Electricity

California leads the world in the development of three forms of alternate energy: geothermal, wind, and solar. The state's geothermal plants, wind farms and solar parks are the world's largest. A single installation in southern California at Kramer Junction produces 90% of the world's solar electric power. It consists of a solar electric generating system known as SEGS, built and designed by Luz International Ltd. Using 600,000 curved glass mirrors water is transformed to steam which fuels a multi-unit 194 MW_e generating system. The power, which is sold to Southern California Edison, currently costs 12 cents per kWh to produce.[24] Rates paid to qualifying facilities such as the solar units under the Public Utilities Regulatory Policies Act of 1978 have not covered the cost of production; however federal and state tax credits and other incentives have kept the company viable since it opened its first 14 MW_e facility in 1984. It reported $5 million profit on $153 million in revenues in 1988[24], primarily from the sale and construction of solar plants. Investments from utilities and insurance companies in the firm are estimated at $750 million. With the expiration of most tax incentives the company's future is cloudy; however it plans a $1.2 billion expansion in 1989 to triple electricity output and to further reduce costs to 8 cents per kWh. At that point its electricity would be nearly competitive with conventional oil- and coal-fired generating plants especially if environmental costs (pollution controls, rehabilitation of strip mines, etc) are added to the price as will be done in California Energy Commission calculations starting in 1990.

METHANOL AS AN ALTERNATE FUEL

The State's program to promote methanol continued to move ahead. In October the federal "Alternative Motor Fuels Act" was signed by President Reagan. The Act was designed to give incentives to automobile manufacturers to produce cars that burn methanol, ethanol and natural gas by giving credit toward their Corporate Average Fuel Economy (CAFE) ratings for gasoline automobiles. By encouraging the development and production of alternate-fueled vehicles the Act gave impetus to the State goal to replace its oldest and least efficient buses and vehicles.with methanol-fueled counterparts. Legislation was signed that authorized the Energy Commission to order 750 new school buses. In addition an agreement was struck with General Motors to provide 2250 methanol-powered automobiles to the State for evaluation. There are already about 700 methanol-fueled automobiles in public and government fleets operating in the state.

The impetus to the methanol program is the acute air pollution problem particularly in the southern portion of the state. While admittedly giving rise to smaller NOx emissions than gasoline-fueled vehicles, other novel emissions such as formaldehyde that are related to methanol combustion have yet to be thoroughly evaluated.

Appendix A

Energy balance for 1988 (Figure 1)

SUPPLY			(10^{12} btu)
Electrical Imports			304
Wind			6
Hydro			89
Cogenerated electricity (fuels included in oil and gas supplies below)			-
Geothermal			182
Nuclear			319
Natural gas			1932
Less: unaccounted for gas and net storage additions			-39
Coal			50
Petroleum			4421
Less exports			-522
Total			6742
DISPOSITION			
Useful energy			2792
Residential/commercial		945	
Industrial		1168	
Transportation		679	
Non-energy uses			235
Rejected energy			3805
Residential/commercial		405	
Industrial		389	
Transportation		2036	
CA electric utility generation		814	
Fossil fuels	444		
Nuclear	214		
Hydro	9		
Geothermal	147		
CA transmission losses		40	
Out-of-state elec. generation and transmission losses		121	
Cogeneration (included in industrial)			-89
Total			6743

Appendix B

Data Sources for California Energy Supply (1988)

Production	Source
Crude Oil including Federal Offshore and Lease Condensate	Ref. 8.
Associated and Nonassociated Natural Gas (Marketed, dry)	Ref. 13, Table 45. Summary Statistics for Natural Gas - California.
Electric Utility Fuel Data	Ref. 20, Table 15. Total Consumption of Petroleum to Produce Electricity. Table 16. Consumption of Gas to Produce Electricity.
Electrical Generation	
Oil, gas, hydro, nuclear,	Ref. 20, Tables 8, 9, 10, 11, and 12. Net Generation by Petroleum Gas, Hydroelectric Power, Nuclear Power and Other.
Wind	Ref. 17.
Cogeneration	Ref. 19.
Imports	
Natural Gas	
Foreign	Ref. 13, Table 9.
Domestic	Ref. 13, Table 45.
Crude Oil Foreign and Domestic	Ref. 25 Table 1. California Petroleum Summary.
Oil Products Foreign and Domestic	Ref. 25, Fourth Quarter, Table A-1. California Petroleum Fuels Market Activity.
Coal	Ref. 26, Table 24. Coal Consumption by Census Division and State.
Electrical Power	
Net Exchange	Ref. 19.
Coal	Ref. 19
Exports	
Oil Products Foreign and Domestic (not including bunkering fuel supplied at California ports)	Ref. 25. Fourth Quarter, Table A-1.

Appendix C

Data Sources for California End Uses (1988)

Net Storage	
Natural Gas	Ref. 13, Table 45
Unaccounted for Natural Gas	Ref. 13, Table 45
Transportation	
Crude Oil	
Gasoline, aviation and jet fuels	Ref. 25, Fourth Quarter, Table A-1. (CA supplied).
Taxable Diesel Fuel (for public highways)	Ref. 27 Table A-11. Sales for Transportation Use: Distillate Fuel Oil and Residual Fuel Oil, 1988.
Vessel Bunkering (includes international bunkering)	Ibid.
Rail Diesel	Ibid.
Military Use	Ref. 27 Table A-12. Sales for Military use: Distillate fuel and Residual Fuel Oil
Natural Gas	
Pipeline fuel	Ref. 13, Table 45
Industrial, Government, Agriculture, etc.	
Natural Gas (includes lease and plant fuel)	Ref. 13, Table 45.
Coal	Ref. 26, Table 24.
Electricity	Ref. 20 Table 26. Sales of Electricity to Ultimate Consumers by Class of Service, Year to date.
Crude Oil	By Difference.
Non Energy Applications	
Crude Oil and LPG	
Asphalt	Ref. 28
Petrochemical feedstock	Ref. 29, Table 8. PAD District V, Supply and Disposition of Crude Oil and Petroleum Products, 1988.
Waxes, lubricating oils, medicinal uses, cleaning	Ref. 25, Table A-5. California Refinery Activity by Type and Area.
Natural Gas	
Fertilizer	Ref. 30

Residential and Small Commercial	
Natural Gas	Ref. 13, Table 45
Crude Oil and Other Oils (kerosene, residual, and distillate)	Ref. 27 Table A-6. Sales of Kerosene by End Use. Table A-5.Sales of Residual Fuel Oil by End Use. Table A-4.Sales of Distillate Fuel Oil by End Use.
LPG	Ref. 29, loc. cit.
Miscellaneous "off highway" Diesel	Ref. 27 Table A-4.
Electricity	Ref. 20 Table 26. Sales of Electricity to Ultimate Consumers by Class of Service, Year to date.

Appendix D

Conversion Units

Energy Source	Conversion factor, 10^6 Btu
Electricity	3.415 per MW.h
Coal 22.6 per short ton	
Natural Gas	1.05 per Mcf
Crude Oil	5.80 per barrel
Fuel Oil	
Residual	6.287 per barrel
Distillate, including diesel	5.825 per barrel
Gasoline and Aviation Fuel	5.248 per barrel
Kerosene	5.67 per barrel
Asphalt	6.636 per barrel
Road Oil	6.636 per barrel
Synthetic Rubber and Miscellaneous	
LPG Products	4.01 per barrel

Assumed Conversion Efficiencies of Primary Energy Supply

Electric Power Generation	
Hydro Power	90%
Coal	30%
Geothermal	18%
Oil and Gas	33%
Uranium	32%
Transportation Use	25%
Residential/Commercial Use	70%
Industrial Use	75%

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